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(54) Fabrication of an internal combustion engine inlet manifold

(57) An internal combustion engine inlet manifold includes two parts of a housing 11 formed by welding a first plastics component 16 to a second plastics component 17 at a pair of abutting non-planar joint faces (27, 28) indicated by a joint line 18, by vibrating one component relative to the other.

The housing 11 includes four inlet tracts (13, Fig.2) each including a curved tract portion defined by a curved duct portion 15. One component 17 is on the inside of the curve and the other component 16 is on the outside, no part of the joint face being inclined at an angle greater than 60 degrees to a plane perpendicular to the direction of a clamping force used in the friction welding.

The joint faces may be provided with respective peripheral lands 37, 39 and 38, 41; and a tongue 29 and abutment surface 33, such that there is an initial predetermined gap between the lands which closes when the vibrations and clamping force are applied, the vibrations being ceased when the gap is eliminated.

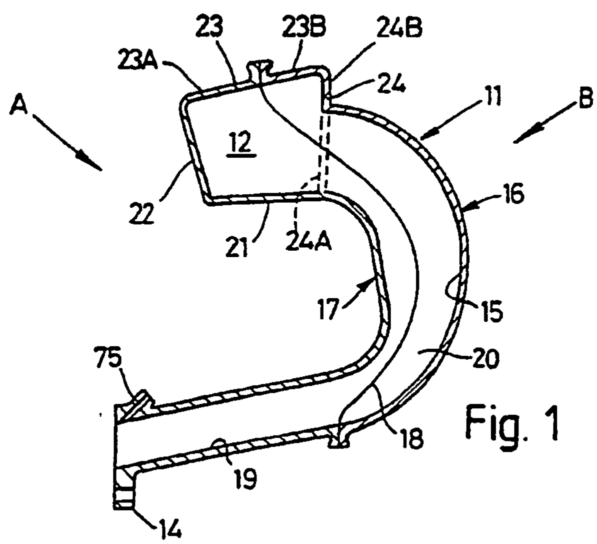

Fig. 1

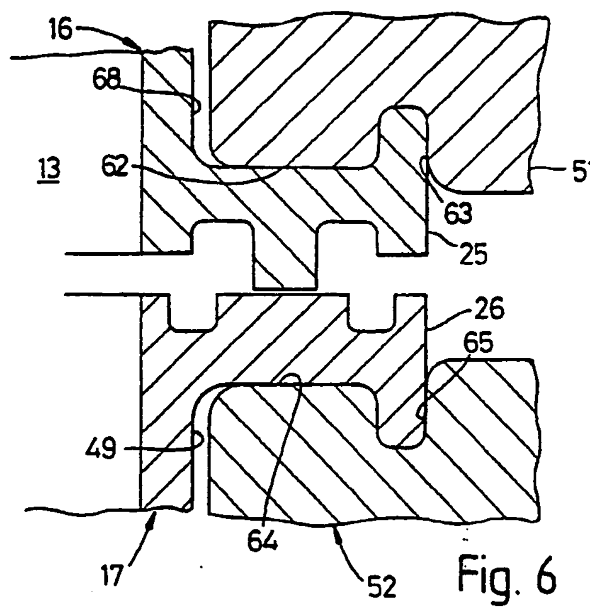

Fig. 6

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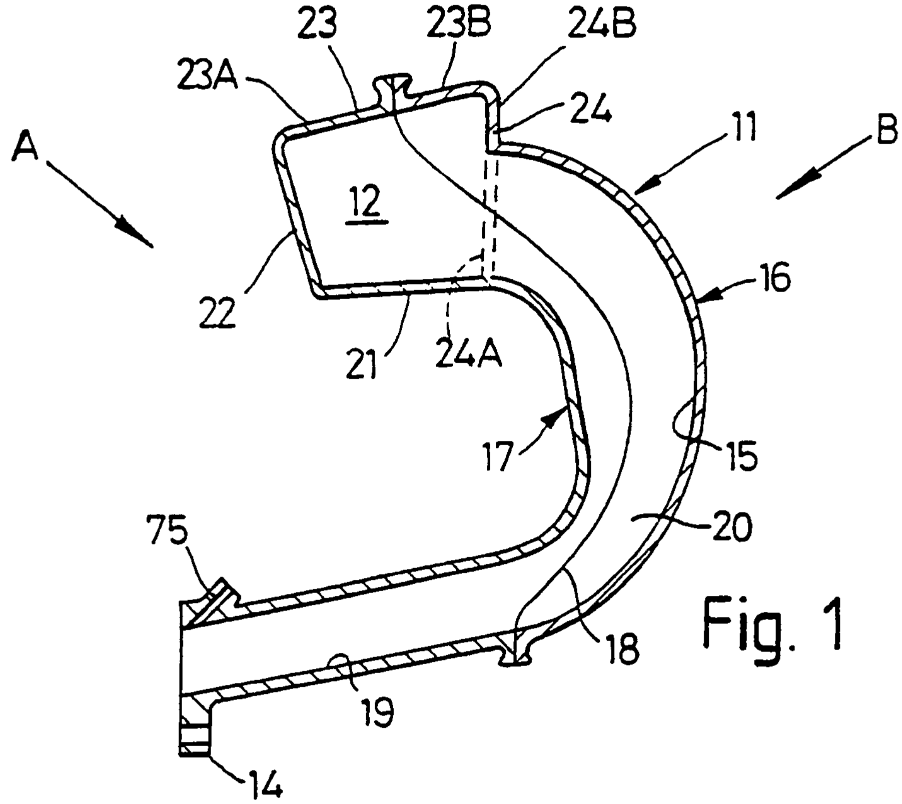
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Fig. 1

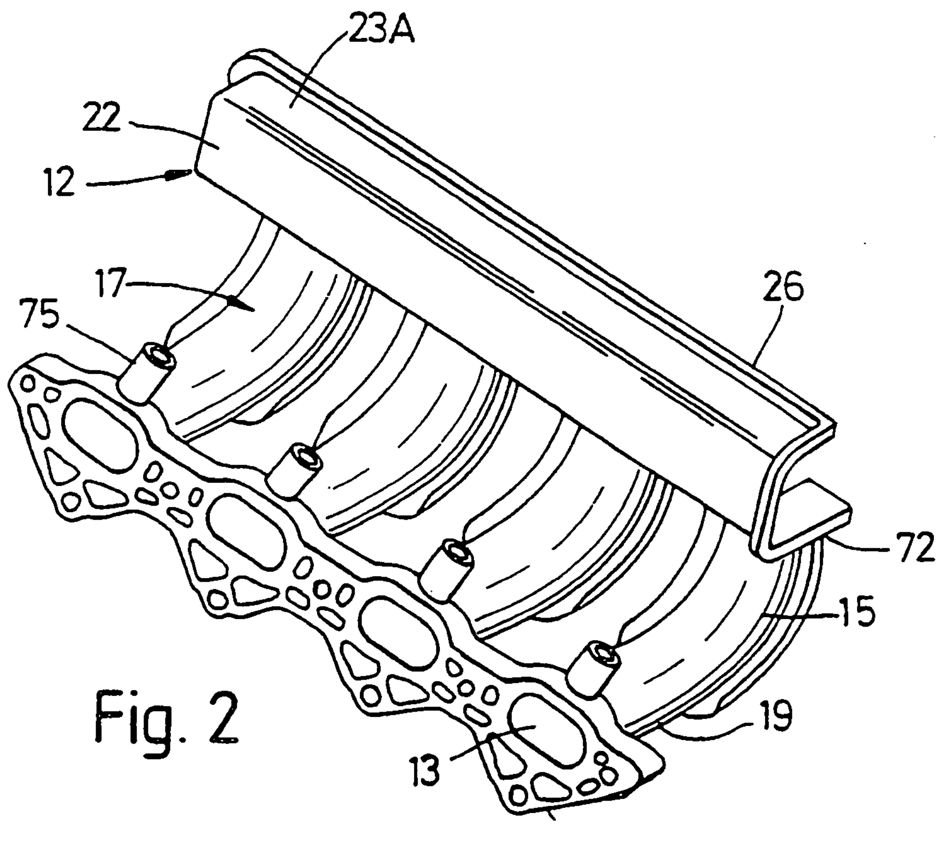
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Fig. 2

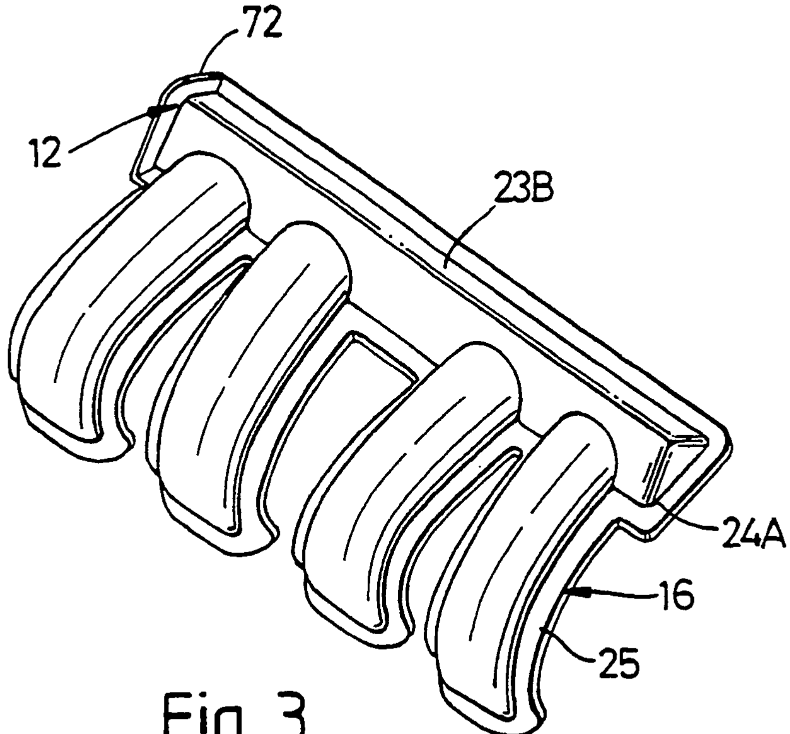

Fig. 3

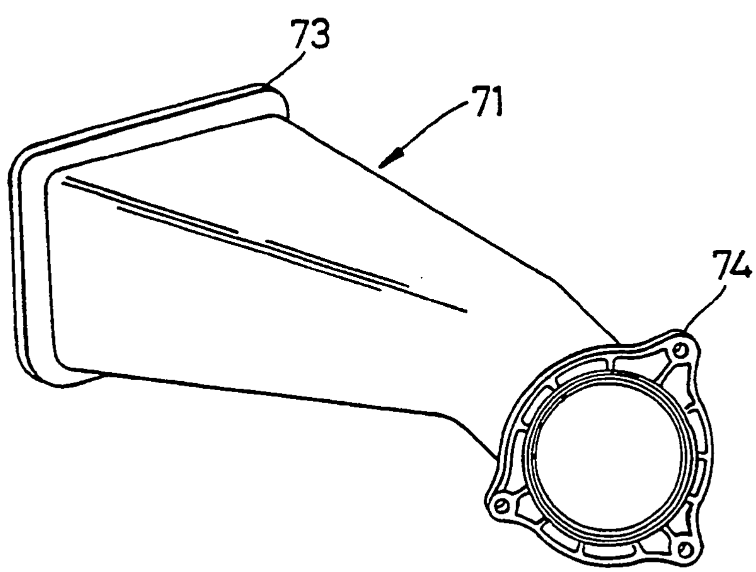

Fig. 9

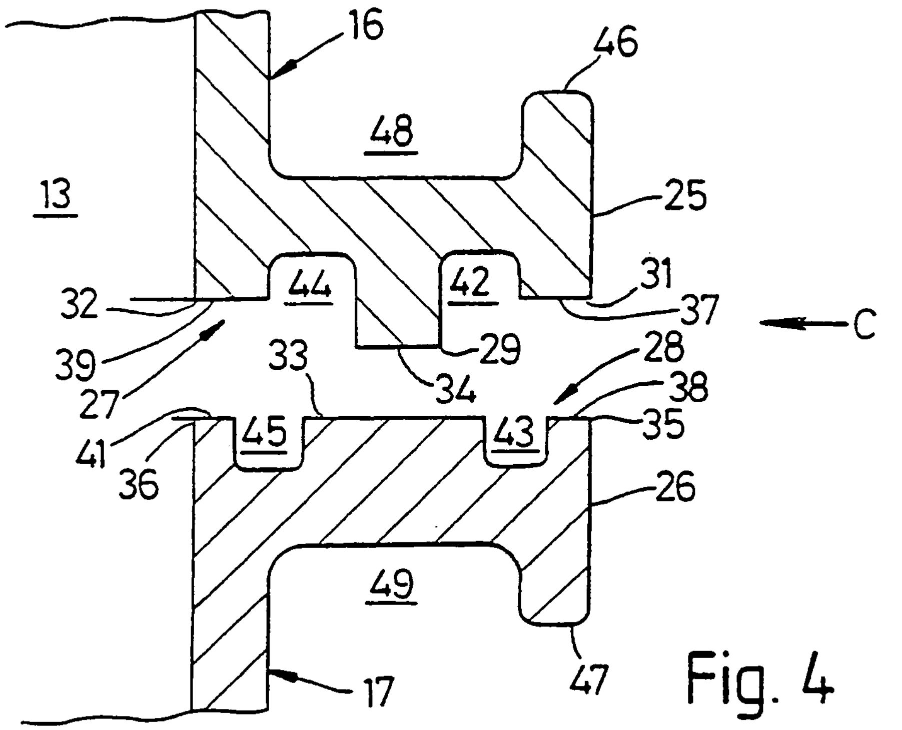
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Fig. 4

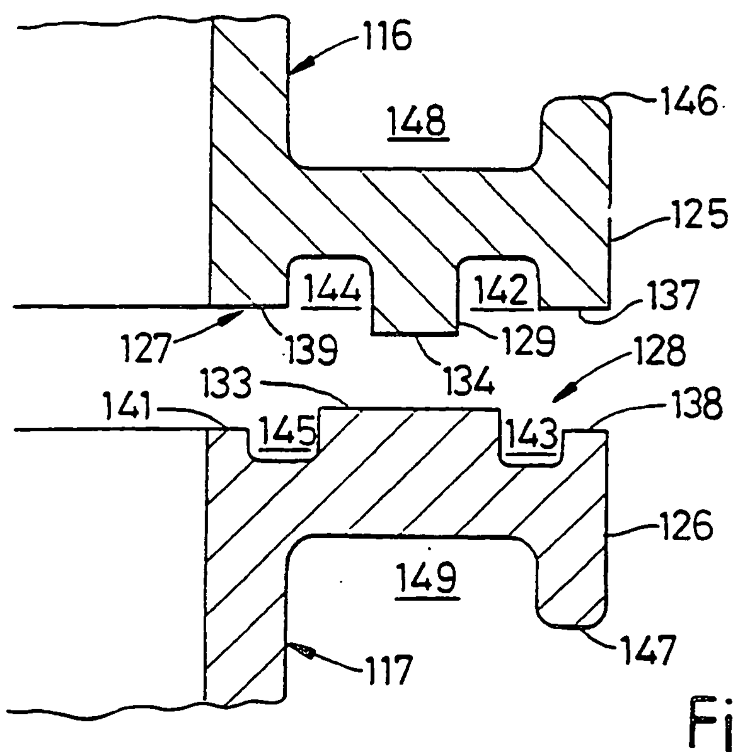
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Fig. 10

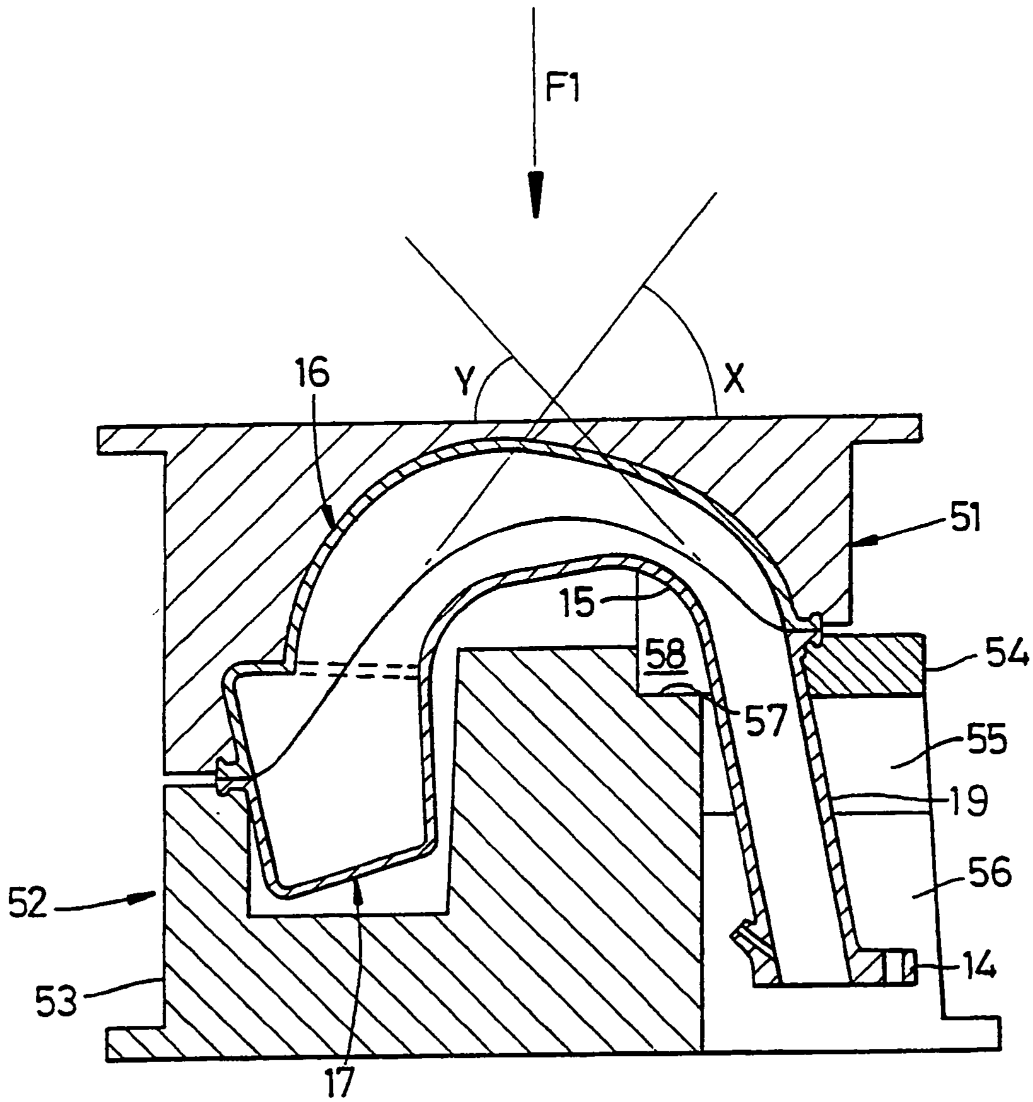

Fig. 5

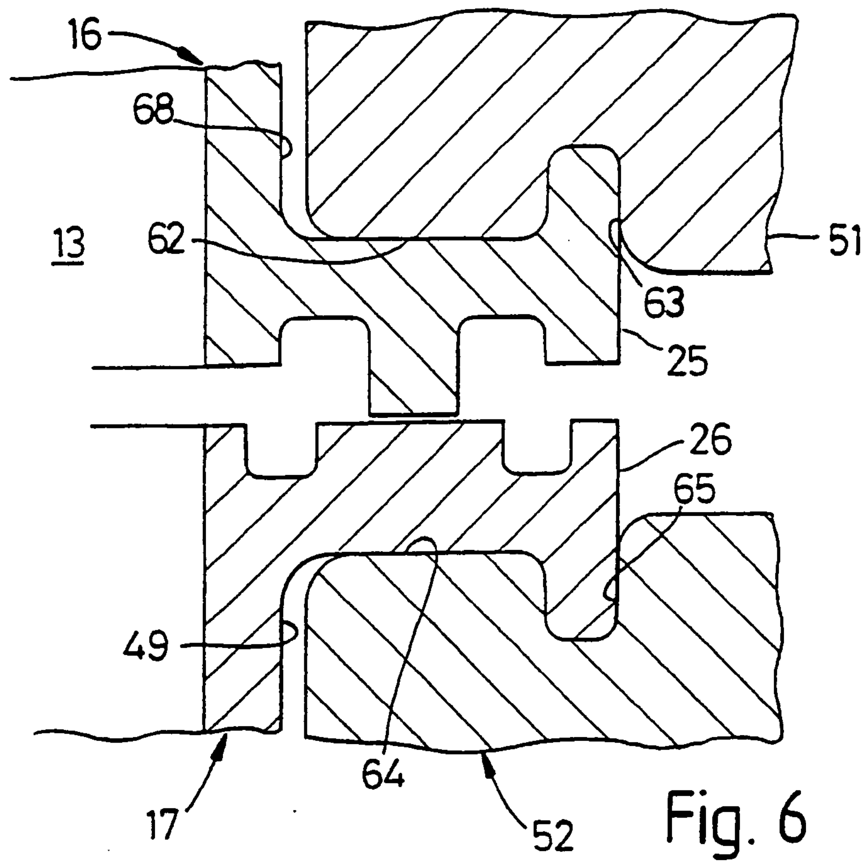
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Fig. 6

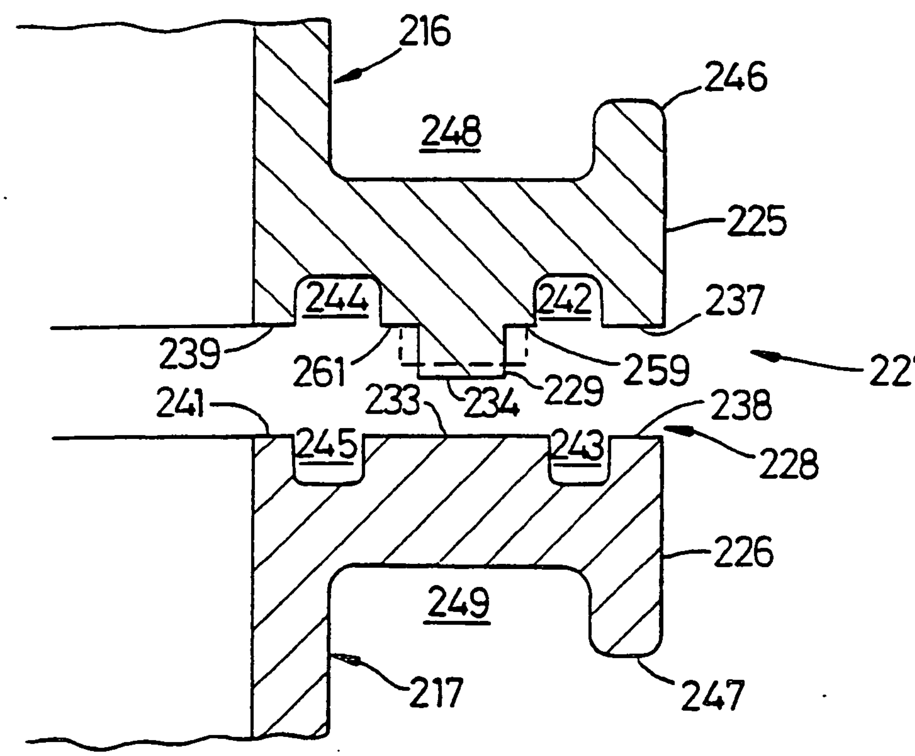
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Fig. 11

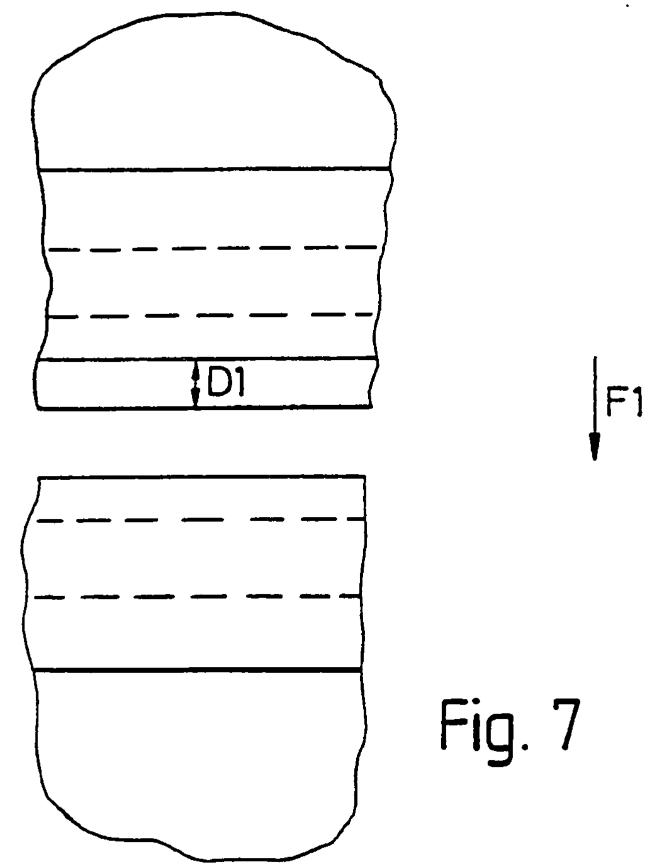

Fig. 7

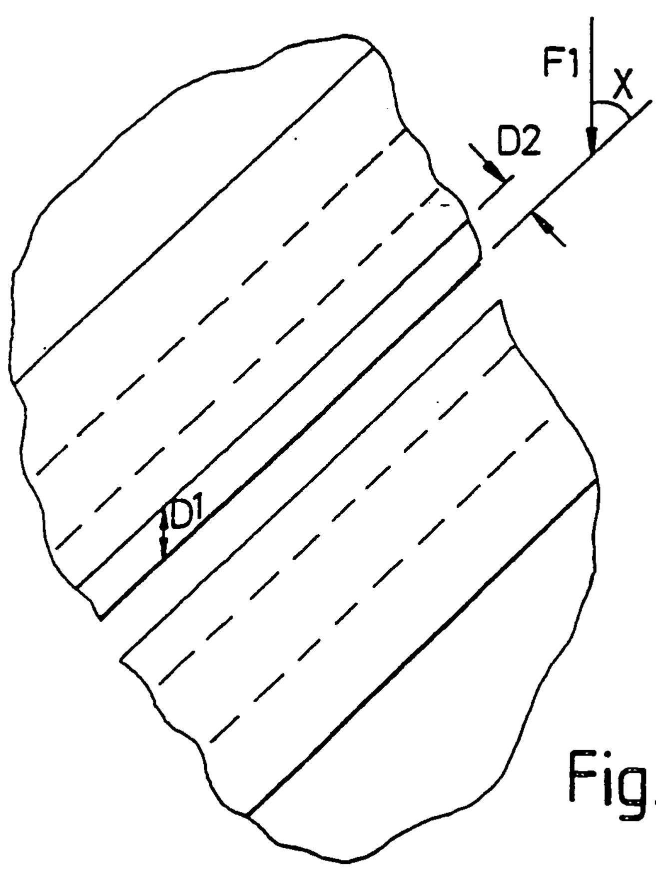

Fig. 8

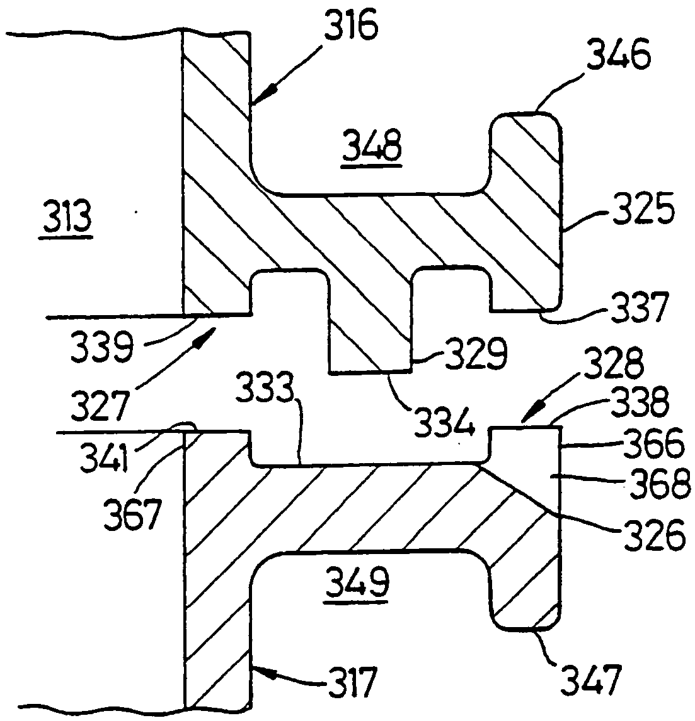
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Fig. 12

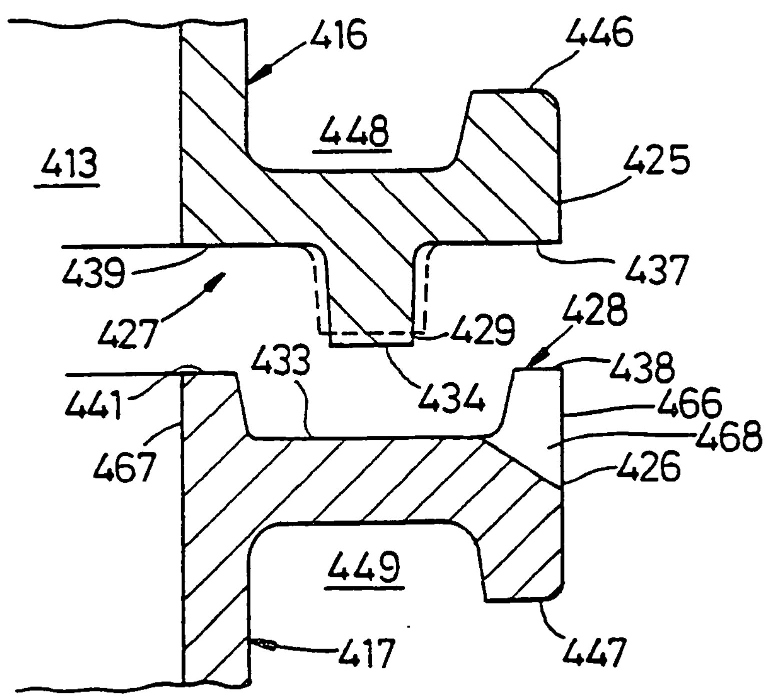
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Fig. 17

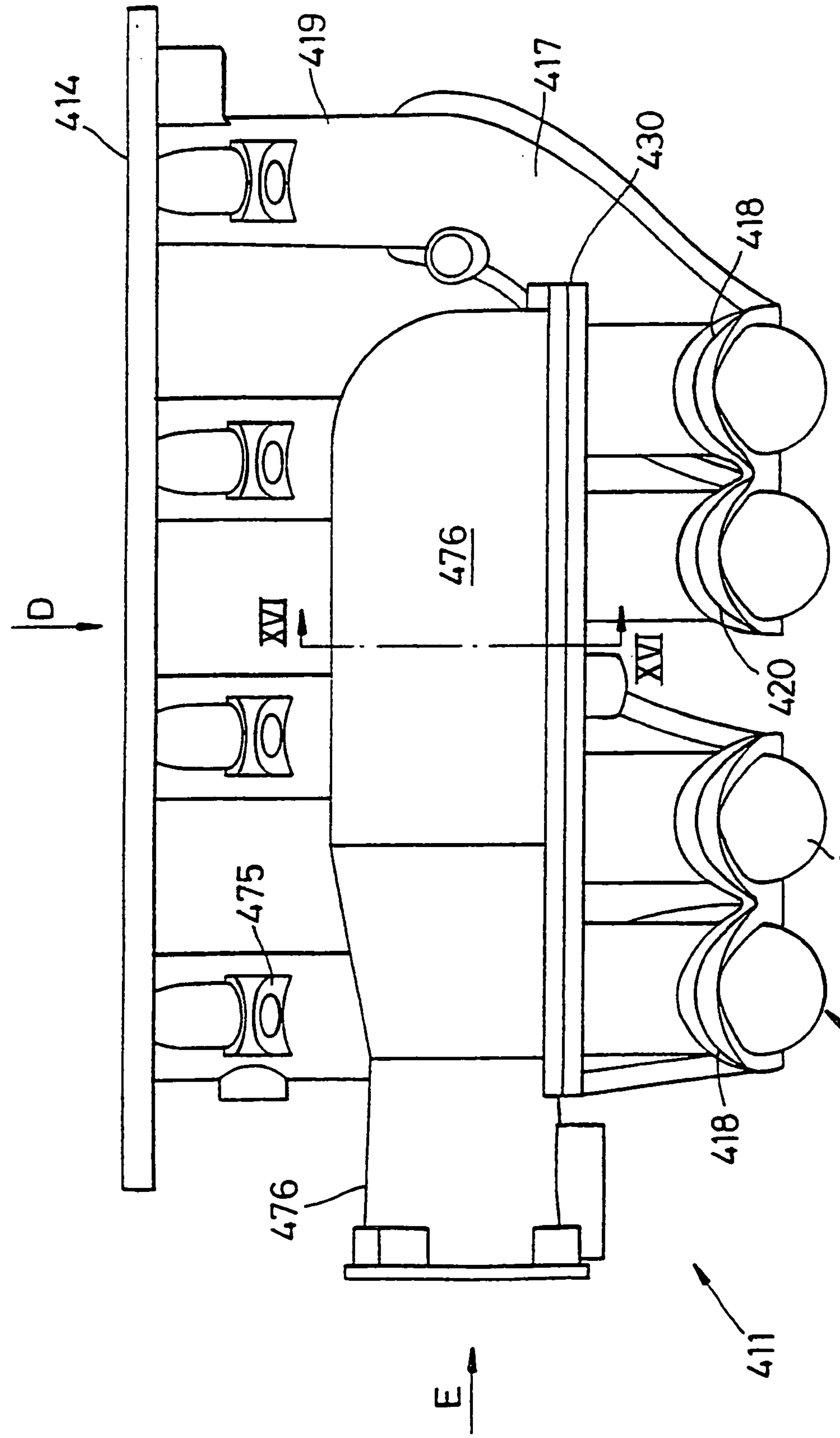

Fig. 13

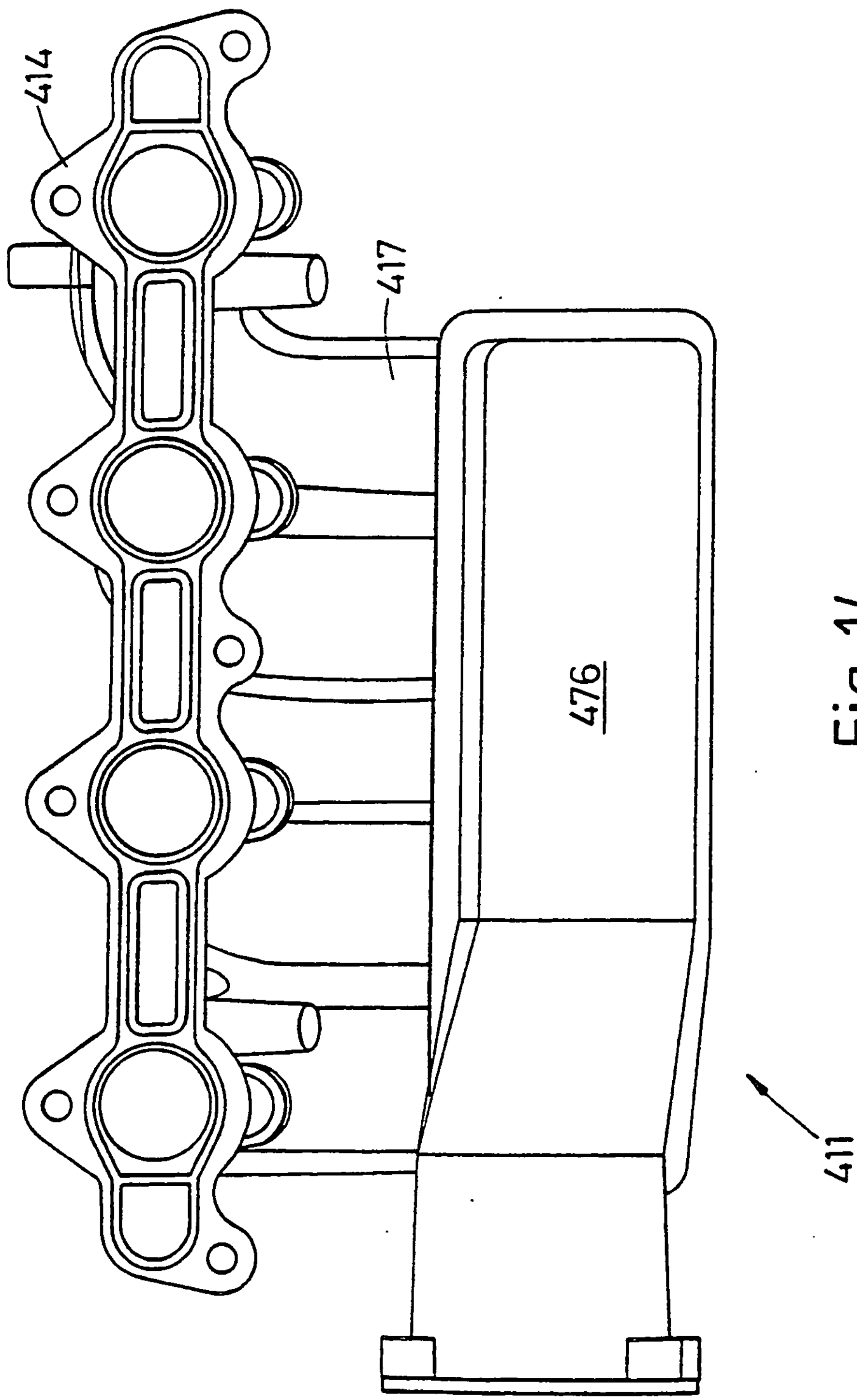

Fig. 14

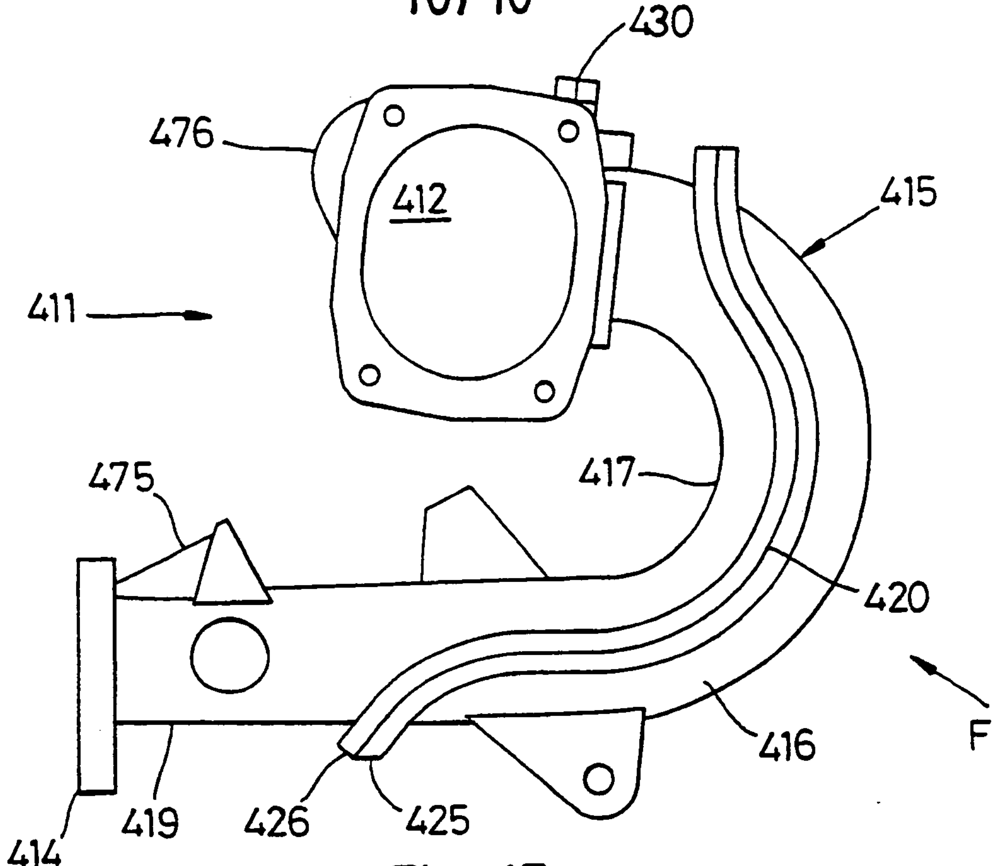

Fig. 15

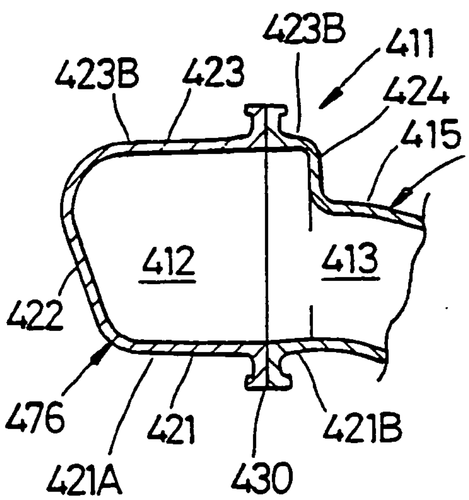

Fig. 16

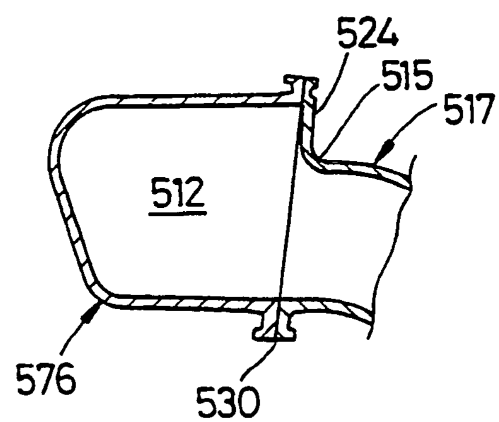

Fig. 18

FABRICATION OF AN INTERNAL COMBUSTION ENGINE INLET MANIFOLD

This invention relates to methods of fabricating an internal combustion inlet manifold and to manifolds made by such methods.

It is known to fabricate internal combustion engine inlet manifolds by forming a first plastics component with a first joint face, forming a second plastics component with a second, complementary, joint face and joining the components at the joint faces.

Particular difficulties arise when the joint faces are non-planar and it is an object of the invention to provide an internal combustion engine inlet manifold and a method of fabrication therefor which overcomes these difficulties.

According to a first aspect of the invention there is provided a method of fabricating an internal combustion engine inlet manifold having a housing defining a plenum, an inlet port to connect the plenum to atmosphere and a number of inlet tracts each connected to and extending from the plenum for connection to an engine to be supplied with air, each inlet tract including a curved tract portion which is defined by a respective curved duct portion of the housing, the method comprising the steps of;

forming a first component of plastics material with a first joint face thereon;

forming a second component of plastics material with a second, complementary, joint face thereon;

aligning the components with the joint faces in substantially uniform contact;

applying a clamping force to create pressure on the joint faces; and

vibrating one component relative to the other whilst maintaining the clamping force to create friction at the joint faces and thereby join the components by welding of the plastics material;

the components being formed so that the joint faces are curved in the region of the curved duct portion so that in said region one component is substantially on the inside of the curve and the other component is substantially on the outside of the curve and arranged so that no part of each joint face is inclined at an angle substantially greater than 60 degrees to a plane perpendicular to the direction of the clamping force.

Each curved duct portion may in use substantially reverse the direction of gas flow through the inlet tract.

Preferably, the joint faces are curved in the opposite direction to the curve of the duct in the region of each end of the curved duct portion, in which case it is preferred that no part of the joint face where curved in said opposite direction is inclined at an angle substantially less than 10 degrees to a plane perpendicular to the clamping force.

Conveniently, the first joint face is formed with a projecting tongue with an end face thereon positioned intermediate two side edges of the first joint face and the second joint face is formed with an abutment surface intermediate two side edges of the second joint face, the arrangement being such that when the clamping force is applied the end face of the tongue abuts the abutment surface. In this case the first joint face may be formed with a first peripheral land adjacent one of the respective side edges, the second joint face being formed with a second peripheral land adjacent one of the respective side edges, the joint faces being arranged so that when the components are aligned with the end face of the tongue in abutment with the abutment surface the peripheral lands are opposite and with a predetermined gap therebetween which is substantially constant in the direction of the clamping force and vibration of one component relative to the other is ceased when the predetermined gap is substantially eliminated.

Conveniently, one of said peripheral lands is on a peripheral rib formed on the joint face of the respective component, the peripheral rib being preferably formed on the same joint face as the abutment surface.

The peripheral rib may be formed with slots which allow inspection of the interface between the end face of the tongue and the abutment surface.

The width of the tongue may be increased in accordance with the inclination of the joint faces to a plane perpendicular to the direction of the clamping force, preferably being varied to provide a substantially constant volume of weld material per unit length of joint face. Said one plastics component may include a flange to connect the manifold to the engine, adjacent duct portion conveniently being interconnected at the flanges to form one single plastics component.

Conveniently, adjacent duct portions of said one plastics component are interconnected by a wall portion of the plenum.

Said one plastics component may comprise a respective straight duct portion between the flange and the curved duct portion and adjacent duct portions of said other plastics component may be interconnected in the region of adjacent portions of the joint faces.

Preferably the method includes the steps of placing the first plastics component in a first tool or jig which supports the first component in the region of the first joint face and placing the second plastics component in a second tool or jig which supports the second component in the region of the second joint face, at least one of the components being flexible so that application of the clamping force causes the joint face of the flexible component to conform to the joint face of the other component and creates pressure on the joint faces over substantially the whole length of the joint face, in which case said one plastics component preferably has substantially greater rigidity than said other plastics component.

According to a second aspect of the invention there is provided an internal combustion engine inlet manifold having a housing defining a plenum, an inlet port to connect the plenum to atmosphere and a number of inlet tracts each connected to an extending from the plenum for connection to an engine to be supplied with air, each inlet tract including a curved tract portion which is defined by a respective curved duct portion of the housing, the housing comprising a first component of plastics material having a first joint face thereon and a second component of plastics material having a second, complementary, joint face thereon, the components being joined by aligning the components with the joint faces in

substantially uniform contact, applying a clamping force to create pressure on the joint faces and vibrating one component relative to the other whilst maintaining the clamping force to create friction at the joint faces and thereby join the components by welding of the plastics material, the joint faces being curved in the region of the curved duct so that in said region one component is substantially on the inside of the curve and the other component is substantially on the outside of the curve and arranged so that no part of each joint face is inclined at an angle substantially greater than 60 degrees to a plane perpendicular to the direction of the clamping force.

Each curved duct portion may in use substantially reverse the direction of gas flow through the inlet tract.

Preferably, the joint faces are curved in the opposite direction to the curve of the duct in the region of each end of the curved duct portions, in which case it is preferred that no part of the joint face where curved in said opposite direction is inclined at an angle substantially less than 10 degrees to a plane perpendicular to the clamping force.

Conveniently, before the components are joined, the first joint face has a projecting tongue with an end face thereon positioned intermediate two side edges of the first joint face and the second joint face has an abutment surface intermediate two side edges of the second joint

face, the arrangement being such that when the clamping force is applied the end face of the tongue abuts the abutment surface. In this case the first joint face may have a first peripheral land adjacent one of the respective side edges and the second joint face have a second peripheral land adjacent one of the respective side edges, the joint faces being arranged so that when the components are aligned with the end of face of the tongue in abutment with the abutment surface the peripheral lands are opposite and with a predetermined gap therebetween which is substantially constant in the direction of the clamping force and vibration of one component relative to the other is ceased when the predetermined gap is substantially eliminated.

Conveniently, one of said peripheral lands is on a peripheral rib formed on the joint face of the respective component, the peripheral rib preferably being on the same joint face as the abutment surface.

The peripheral rib may have slots which allow inspection of the interface between the end face of the tongue and the abutment surface.

The width of the tongue may be increased in accordance with the inclination of the joint faces to a plane perpendicular to the direction of the clamping force, preferably being varied to provide a substantially

constant volume of weld material per unit length of joint face.

Said one plastics component may include a flange to connect the manifold to the engine, adjacent duct portion conveniently being interconnected at the flanges to form one single plastics component.

Conveniently, adjacent duct portions of said one plastics component are interconnected by a wall portion of the plenum.

Said one plastics component may comprise a respective straight duct portion between the flange and the curved duct portion and adjacent duct portions of said other plastics component may be interconnected in the region of adjacent portions of the joint faces.

Said one plastics component preferably has substantially greater rigidity than said other plastics component.

Other aspects of the invention will be apparent from the appended Claims and from the following description of the invention which is given by way of example and with reference to the accompanying drawings, of which:-

Figure 1 is a cross-sectional view of a first embodiment of composite plastics structure fabricated

according to the invention and comprising part of an internal combustion engine inlet manifold;

Figure 2 is a perspective view of one component of the structure shown in Figure 1 in the directions of arrow A;

Figure 3 is a perspective view of another component of the structure shown in Figure 1 in the direction of arrow B;

Figure 4 shows magnified and in greater detail a pair of abutting joint faces of the components shown in Figures 1 to 3 before joining;

Figure 5 shows the components shown in Figures 1 to 4 mounted in tools in preparation for joining at the joint faces;

Figure 6 is a view similar to Figure 4 showing the abutting joint faces when the components are mounted in the tools shown in Figure 5;

Figure 7 is a view on arrow C in Figure 4;

Figure 8 is a view similar to Figure 7 showing the joint faces inclined to the clamping force F shown in Figure 5.

Figure 9 is a perspective view of an inlet flange adapter which when added to the structure shown in Figures

1 to 3 completes the main structure of the internal combustion engine inlet manifold;

Figure 10 is a view similar to Figure 4 showing a first modification;

Figure 11 is a view similar to Figure 4 showing a second modification;

Figure 12 is a view similar to Figure 4 showing a third modification;

Figure 13 is a plan view of a second embodiment of a composite plastics structure fabricated according to the invention and comprising an internal combustion engine inlet manifold;

Figure 14 is an elevation on arrow D in Figure 13;

Figure 15 is an end elevation on arrow E in Figure 13;

Figure 16 is a partial cross-section on the line XVI-XVI in Figure 13;

Figure 17 shows magnified and in greater detail a pair of abutting joint faces of the components shown in Figures 13 to 16; and

Figure 18 is a cross-section similar to Figure 16 showing a modification.

Referring to Figure 1, the composite plastics structure shown forms a housing 11 which defines a plenum 12 and four inlet tracts 13, each connected to and extending from the plenum. The structure forms part of an inlet manifold for connection to the cylinder head of an internal combustion engine by a flange 14 so that the inlet tracts 13 can supply air to the inlet ports of the engine.

Each inlet tract 13 is defined by a respective inlet duct 20 and includes a curved tract portion defined by a respective curved duct portion 15 of the housing 11. The extent of the curve is such that each curved duct portion in use substantially reverses the direction of gas flow through the inlet tract, i.e., the arc of the curved duct portion extends over an angle substantially greater than 90 degrees but substantially less than 270 degrees.

The housing 11 comprises first and second components 16 and 17 of plastics material joined at a pair of abutting joint faces, indicated in Figure 1 by a joint line 18.

Figure 2 shows the second component 17 in more detail and Figure 3 shows the first component 16. The joint line 18 passes through the region of each curved duct portion 15 such that the first component 16 is on the outside of the curve and the second component 17 is on the inside of the curve, the joint faces being curved in the opposite direction to the curve of the duct in the region of each end of the curved duct portion. The second component 17

includes the flange 14 which interconnects adjacent duct portions 15, there being a respective straight duct portion 19 interposed between the flange and each curved duct portion 15.

Where the housing 11 defines the plenum 12, it comprises a base wall portion 21, a rear wall portion 22, a top wall portion 23 and a front wall portion 24. The base wall portion 21, the rear wall portion 22, the rear part 23A of the top wall portion 23 and the lower part 24A of the front wall portion 24 also serve to interconnect adjacent curved duct portions 15 of the second component 17.

Adjacent duct portions of the first plastics component 16 are interconnected by other wall portions of the plenum 12, these comprising the upper part 24B of the front wall portion 24 and the front part 23B of the top wall portion 23.

Each plastics component 16 and 17 has a flange 25 and 26 respectively. Figure 4 shows the flanges 25 and 26 in greater detail with the components 16 and 17 aligned preparatory to being joined together.

A first joint face 27 is on the flange 25 of the first component 16 and a second joint face 28 is on the flange 26 of the second component 17. The first joint face 27 has a projecting tongue 29 positioned intermediate two

side edges 31 and 32 of the joint face. Side edge 31 is on the outside of the flange 25 whereas side edge 32 is on the inside, adjacent the inlet tract 13.

The second joint face 28 has an abutment surface 33 positioned opposite an end face 34 on the tongue 29 and interposed between an outer side edge 35 and an inner side edge 36. The first joint face 27 includes a first peripheral land 37 adjacent outer side edge 31. Similarly the second joint face 28 includes a second peripheral land 38 adjacent outer side edge 35. A third peripheral land 39 is adjacent the inner side edge 32 of the first joint face 27 and a fourth peripheral land 41 is adjacent the inner side edge 36 of the second joint face 28.

A groove 42 is between the tongue 29 and the first land 37, a groove 43 is between the abutment surface 33 and the second land 38, a groove 44 is between the tongue and the third land 39 and a groove 45 is between the abutment surface and the fourth land 41.

A peripheral rib 46 is formed on flange 25 on the opposite side to the first joint face 27 and a peripheral rib 47 is formed on flange 26 on the opposite side to the second joint face 28. Between each rib 46, 47 and the adjacent wall of the housing 11 there is a respective groove 48, 49 which together with the associated rib acts as a formation for engagement with a respective tool 51, 52 during joining of the joint faces.

Figure 5 and Figure 6 show the first and second components 16 and 17 engaged in the tools 51 and 52 prior to joining at the joint faces 27 and 28. The upper tool 51 is in one piece and generally follows the contours of the first component 16. The lower tool 52 is in two parts comprising a base portion 53 and a closing piece 54. The base portion 53 has slots 55 to provide clearance for the straight duct portions 19, a recess 56 to provide clearance for the flange 14 and a recess 57 to locate the closing piece 54. Slots 58 in the closing piece 54 give clearance for the curved duct portions 15 adjacent the junction with the straight duct portions 19.

In the region of the flange 25 the upper tool 51 is profiled with a contact surface 62 to abut the base of the groove 48 and a groove 63 to engage the rib 46 and thereby support the first component 16 in the region of the first joint face 27. Similarly, in the region of the flange 26 the lower tool 52 is profiled with a contact surface 64 to abut the base of the groove 49 and a groove 65 to engage the rib 47 and thereby support the second component 17 in the region of the second joint face 28.

In use the upper tool 51 is attached to the movable platen of a friction welding machine and the lower tool 52 is attached to the fixed platen. The movable platen can exert a clamping force on the joint faces in the direction of arrow F1 and can reciprocate in a direction normal to the section shown in Figure 5.

From Figure 7 it can be seen that where the joint face is perpendicular to the clamping force F1 the tongue 29 extends beyond the first and third peripheral lands 37 and 39 by an amount D1. The abutment surface 33 is level with the second and fourth peripheral lands 38 and 41 so that when the end face 34 of the tongue 29 is in contact with the abutment surface 33 there is a predetermined gap between the first and second lands 37 and 38 equal to the distance D1.

Where part of each joint face 27 and 28 is inclined to a plane perpendicular to the direction of the clamping force as indicated by angle X in Figure 6 and illustrated by Figure 8, the predetermined gap is reduced to a distance D2 given by D1.Cosine X when measured between the lands 37 and 38, the distance in the direction of the clamping force remaining constant at D1.

To join the components 16 and 17 the components are aligned in the tools 51 and 52 with the end face 34 of the tongue 29 in contact with the abutment surface 33. The components 16 and 17 are previously formed from a thermoplastics material using conventional injection moulding equipment and techniques. However, the nature of moulding a complex shape with wall sections without added stiffening ribs is that the final shape is not easy to predict from the mould design. To allow for this, at least one of the components, in this case the first

component 16, is designed to be relatively flexible both in torsion and in bending.

The flexibility of component 16 allows the contact surface 62 and the groove 63 on the upper tool 51 to be made according to the shape of 26 of the second component 17. Contact surface 64 and groove 65 on the lower tool 52 are made to suit the second component 17 in its "as moulded" condition and contact surface 62 and groove 63 on the upper tool 51 are positioned so as to align the tongue 29 relative to the abutment surface 33 and to ensure a uniform spacing between the tongue end face 34 and the abutment surface in the direction of the clamping force F1 as described above.

Hence the groove 63 cooperates with the rib 46 on the first component to correct any misalignment of the first component 16 relative to the second component 17.

Similarly, whilst there may be distortion of the first component which allows a varying clearance between the contact surface 62 on the upper tool 51 and the base of groove 48 in the flange 25, when the clamping force F1 is applied, the reaction force between the rib end face 34 and the abutment surface 33 forces the first component to conform to the tool where it contacts the flange 25 and any clearance between the contact surface 62 and the base of groove 48 is closed up. There is then substantially uniform contact between the tongue end face 34 and the

abutment surface 33 over the whole length of the tongue, the joint face of the first component being forced to conform to the joint face of the second component and create pressure on the joint faces over substantially their whole length.

With the clamping force F1 maintained, the upper tool 51 is vibrated in the direction previously indicated. Friction between the tongue 29 and the abutment surface causes local melting of the plastics material sufficient to cause melting of the tongue and the abutment surface. The vibration continues for a fixed time to substantially eliminate the gap between the first and second lands 37 and 38 and between the third and fourth lands 39 and 41.

The clamping force F is maintained for a fixed cooling time after ceasing vibrations to allow the weld material to solidify. The grooves 42, 43, 44 and 45 provide clearance spaces into which the molten plastics can flow from the interface between the tongue 29 and the abutment surface without disturbing the surface of the inlet tracts 13 or creating an unsightly appearance at the flanges 25 and 26.

In a particular example the tongue 29 was 3 mm wide at the end face 34 and projected to give a predetermined gap between the first and second lands of between 1.0 and 1.2 mm. This dimension, which could be described as the tongue melt-down distance, was subject to a variation of

between 0 and 0.5 mm according to the actual gap between the tongue end face and the abutment surface adjacent to the point of measurement. Both components were formed from Du Pont glass filled nylon type Zytel 70G30 and the welding equipment was a Bielomatik K3215 applying a force F1 equivalent to a mean pressure of 90 bar at the tongue end face. "Zytel" and "Bielomatik" are Registered Trade Marks. The upper tool was vibrated at a frequency of 235 Hz at an amplitude of 2.0 mm for a fixed time of 15 seconds and the force F1 maintained for a fixed cooling time of 8 seconds.

The materials and parameters chosen in the particular example would be varied where components of different shape, size and purpose are used and would be subject to appropriate experimentation.

It has been found that by ensuring substantially uniform contact between the tongue end face 34 and the abutment surface prior to vibrating one component relative to the other the time for the vibration can be substantially reduced. This means that where the joint face 27 is inclined to the direction of the clamping force, that is inclined at an angle to a plane perpendicular to the direction of the clamping force as indicated by angles X and Y in Figure 8, then the projecting distance of the tongue has to be reduced as previously indicated. In practice, conformity to within 0.5 mm under the clamping load L gives the required

reduction in the vibration time. Measurement of this conformity is assisted by ensuring that the interface between the end face 34 of the tongue is within the gap between the first and second lands 37 and 38. This allows inspection of the interface between the end face of the tongue and the abutment surface and facilitates the use of optical or feeler type measuring equipment.

To complete the inlet manifold the inlet flange adapter 71 shown in Figure 9 is connected to the open end of the plenum 12. Figures 2 and 3 each show part of a flange 72 at the plenum open end and this is connected to a flange 73 on the adapter 71 using similar friction welding techniques to those described above. The adapter 71 has another flange 74 for connection to a throttle valve assembly which, in use, is connected to an air filter to control the flow of air to the inlet manifold. Bosses 75 on the second component 17 are provided for fuel injection nozzles.

In the first modification shown in Figure 10 features which are the same or similar to those in Figures 1 to 4 are given the same reference numeral with the addition of 100. It shows that the abutment surface 133 can be above the second peripheral land 138, although it is not necessary that it be level with or above the fourth land 141, except to provide suitable dimensions for the grooves 144 and 145.

In the second modifications shown in Figure 11 features which are the same or similar to those in Figures 1 to 4 are given the same reference numeral with the addition of 200. It shows that the grooves 242 and 244 can be distanced from the tongue 229 by a fifth land 259 and a sixth land 261. This makes the opposite grooves 242 and 243, 244 and 245 more closely aligned and enables the welding equipment to be controlled by monitoring the power required for vibrations. When the abutment surface 233 contacts the fifth and sixth lands 259 and 261 there is an increase in the power requirement and this can be used to switch off the vibrations. Friction between the opposing lands 237 and 238 or 239 and 241 can be used to similar effect. Alternatively, the gap D1 can be monitored and the vibration ceased when it has reduced to a specific magnitude.

Figure 11 also shows how the thickness of the tongue 229 can be increased in accordance with the inclination of the joint faces to a plane perpendicular to the direction of the clamping force. Thus, for example, if the cross-sectional area of the tongue is substantially constant in a plane normal to the end face 234 the amount of melt material per unit length of joint face remains the same to keep a uniform weld.

In the third modification shown in Figure 12 features which are the same or similar to those shown in Figures 1 to 4 are given the same reference numeral with the

addition of 300. The form of the flange 325 of the first component 316 is substantially the same as that of flange 25 in Figure 4. However, the flange 326 differs in that the second land 338 is formed on a first peripheral rib 366 which projects beyond the abutment surface in the direction of the flange 325 on the first component. Similarly the fourth land 341 is formed on a second peripheral rib 367 which also projects beyond the abutment surface in the direction of the first component. There are no grooves between the abutment surface 333 and the second and fourth lands 338 and 341 so the abutment surface forms the base of a U shaped groove formed by the peripheral ribs.

In the embodiment described with reference to Figures 1 to 9 and the modifications described with reference to Figures 10 and 11, the fact that the tongue extends beyond the first land and that the abutment surface is level with or above the second land means that the line of contact between the tongue end face and the abutment surface is visible from outside the common joint face, allowing the use of feeler gauges or more sophisticated optical methods of checking the fit of these surfaces as described earlier. In the third modification this is allowed by the use of slots 368 which interrupt the first peripheral rib 366 at intervals around the flange 326. These slots 368 extend below the abutment surface.

It has been found that there are limitations on the maximum angle X or Y by which the joint face is inclined to a plane perpendicular to the direction of the clamping force and for successful results 60 degrees appears to be the maximum. It follows that since one joint face must be reciprocated relative to the other this is measured in a direction perpendicular to the direction of vibration.

In the second embodiment of the invention now described with further reference to Figures 13 to 16, features which are the same or similar to those in Figures 1 to 4 are given the same reference numeral with the addition of 400.

A housing 411 defines a plenum 412 and four inlet tracts 413, each connected to and extending from the plenum. The housing 411 forms part of an inlet manifold for connection to the cylinder head of an internal combustion engine by a flange 414.

Each inlet tract 413 is defined by an inlet duct 420 includes a curved tract portion defined by a respective curved duct portion 415 of the housing 411. In use, each curved duct portion 415 substantially reverses the direction of gas flow through the inlet tract from the plenum 412 to the outlets at the flange 414.

The housing 411 comprises components 416 and 417 of plastics material joined at abutting joint faces.

Each duct 420 is made up of a first component 416 and a second component 417, joined at a curved joint line 418 which passes through the region of each curved duct portion 415 such that the first component 416 is on the outside of the curve and the second component 417 is on the inside of the curve. The second component 417 is common to all four inlet ducts and includes the flange 414 which interconnects adjacent duct portions 415, there being a respective straight duct portion 419 interposed between the flange and each curved duct portion 415. On the other hand, the first component 416 is common to adjacent pairs of ducts 420, so that there are two to make up the four ducts.

Where the housing 411 defines the plenum 412, it comprises a base wall portion 421, a rear wall portion 422, a top wall portion 423 and a front wall portion 424. The front part 421B of the base wall portion 421, the front part 423B of the top wall portion 423 and the front wall portion 424 also serve to interconnect adjacent curved duct portions 415.

The other wall portions of the housing 411 which define the plenum 412 form parts of a third plastics component 476, these comprising the rear part 421A of the base wall portion 421, the rear wall portion 422 and the rear part 423A of the top wall portion 423, the joint line with the second component 417 being indicated at 430.

Each of the first and second plastics components 416 and 417 has a flange 425 and 426 respectively. Figure 17 shows the flanges 425 and 426 in greater detail with components 416 and 417 aligned preparatory to being joined together.

In most respects the details of flanges 425 and 426 are similar to those of flanges 325 and 326 shown in Figure 12. The principle differences are that surface 427 has no grooves between the lands 437 and 439 and that ribs 466 and 467 are correspondingly deeper.

Adjacent curved duct portions 415 of the first plastics component 416 are interconnected in the region of adjacent portions of the joint face 427 by the merging of adjacent portions of the joint flanges 425 to form two siamezed pairs.

The first and second components 416 and 417 are assembled using tools and methods substantially as described in relation to the first embodiment of the invention, an upper tool being profiled with a contact surface to abut the base of groove 448 and to engage rib 446. Similarly, the lower tool is profiled to abut the base of groove 449 and to engage rib 447.

In use the upper tool is attached to the movable platen of a friction welding machine and the lower tool is attached to the fixed platen. The movable platen can

exert a clamping force on the joint faces in the direction of arrow F2 and can reciprocate in a direction normal to the section shown in Figure 16, i.e. in the same direction as arrow E in Figure 13.

From Figure 17 it can be seen that the tongue 429 extends beyond the first and third peripheral lands 437 and 439 by an amount which is greater than the projection of the ribs 466 and 467. Thus when the end face 434 of the tongue 429 is in contact with the abutment surface 433 there is a predetermined gap between the first and second lands 437 and 438.

As with the first embodiment of the invention described with reference to Figures 1 to 9, this predetermined gap is constant in the direction of the clamping force F2 including areas where each joint face 427 and 428 is inclined to a plane perpendicular to the direction of the clamping force.

Figure 17 also shows (in dashed lines) how the thickness of the tongue 429 can be increased where the joint faces are inclined to the direction of the clamping force so that the volume of melt material per unit length of joint face remains substantially constant to keep a uniform weld.

To join the components 416 and 417 the components are aligned in the tools with the end face 434 of the tongue

429 in contact with the abutment surface 433, the components 416 and 417 having been previously formed from a thermoplastics material using conventional injection moulding equipment and techniques. Each of the first components 416 is designed to be relatively flexible both in torsion and in bending to provide substantially uniform contact between the tongue end face 434 and the abutment surface 433 over the whole length of the tongue as previously described in respect of the first embodiment.

With the clamping force F2 maintained, the upper tool is vibrated in the direction previously indicated. Friction between the tongue 429 and the abutment surface 433 causes local melting of the plastics material sufficient to cause melting of the end portion of the tongue and the abutment surface. The vibration continues for a fixed time to substantially eliminate the gap between the first and second lands 437 and 438 and between the third and fourth lands 439 and 441.

The clamping force F2 is maintained for a fixed cooling time after ceasing vibrations to allow the weld material to solidify. The ribs 466 and 467 provide clearance spaces each side of the tongue 429 into which the molten plastics can flow without disturbing the surface of the inlet tracts 13 or creating an unsightly appearance at the flanges 25 and 26. Slots 468 allow inspection of the interface between the tongue 429 and the abutment surface 433.

To complete the inlet manifold, the third plastics component 476 is connected to form the plenum 412 using similar friction welding techniques to those described above. The third component 476 has a flange 474 for connection to a throttle valve assembly which, in use, is connected to an air filter to control the flow of air to the inlet manifold. Bosses 475 on the second component 417 are provided for fuel injection nozzles.

In the modification shown in Figure 18 features which are the same or similar to those in Figures 13 to 17 are given the same reference numeral with the addition of 100. It shows that the joint line 530 between the second component 517 and the third component 576 can coincide with the inside of the front wall 524 of the plenum 512, thereby simplifying the manufacture of the second component 517.

As with the first embodiment of the invention the angle by which the joint face is inclined to a plane perpendicular to the direction of the clamping force F2 is kept within a 60 degrees maximum. Similarly, it is advantageous to ensure that where the joint faces are curved in the opposite direction to the curve of the duct in the region of either end of the curved duct portion then no part of the joint face should be inclined at an angle substantially less than 10 degrees to a plane perpendicular to the clamping force.

Flexibility of one component relative to the other is achieved by attention to the design of the cross-section and minimisation of the wall thickness. However, it can also be helped by selection of materials. For example, the second component 17 or 417 may be of a glass-filled nylon such as Zytel 70G30 and the first material made in a mineral-filled nylon such as Minlon 10B104, both by Du Pont. Zytel 70G30 has a flexural modulus of 5 Geiger Pascals whereas Minlon 10B104 has a flexural modulus of 3 Geiger Pascals. "Minlon" is a Registered Trade Mark.

Although the invention has been described by way of example with reference to a composite plastics structure in the form of an internal combustion engine inlet manifold, the invention may be used in the manufacture of other composite plastics structure which comprise two components joined at a pair of abutting non-planar joint faces.

CLAIMS

1. A method of fabricating an internal combustion engine inlet manifold having a housing defining a plenum, an inlet port to connect the plenum to atmosphere and a number of inlet tracts each connected to and extending from the plenum for connection to an engine to be supplied with air, each inlet tract including a curved tract portion which is defined by a respective curved duct portion of the housing, the method comprising the steps of;

forming a first component of plastics material with a first joint face thereon;

forming a second component of plastics material with a second, complementary, joint face thereon;

aligning the components with the joint faces in substantially uniform contact;

applying a clamping force to create pressure on the joint faces; and

vibrating one component relative to the other whilst maintaining the clamping force to create friction at the joint faces and thereby join the components by welding of the plastics material,

the components being formed so that the joint faces are curved in the region of the curved duct portion so that in said region one component is substantially on the inside of the curve and the other component is substantially on the outside of the curve and arranged so that no part of each joint face is inclined at an angle substantially greater than 60 degrees to a plane perpendicular to the direction of the clamping force.

2. A method according to Claim 1 wherein each curved duct portion in use substantially reverses the direction of gas flow through the inlet tract.

3. A method according to Claim 1 or Claim 2 wherein the joint faces are curved in the opposite direction to the curve of the duct in the region of each end of the curved duct portions.

4. A method according to Claim 3 wherein no part of the joint face where curved in said opposite direction is inclined at an angle substantially less than 10 degrees to a plane perpendicular to the clamping force.

5. A method according to any preceding claim wherein the first joint face is formed with a projecting tongue with an end face thereon positioned intermediate two side edges of the first joint face and the second joint face is formed with an abutment surface intermediate two side edges of the second joint face, the arrangement being

such that when the clamping force is applied the end face of the tongue abuts the abutment surface.

6. A method according to Claim 5 wherein the first joint face is formed with a first peripheral land adjacent one of the respective side edges and the second joint face is formed with a second peripheral land adjacent one of the respective side edges, the joint faces being arranged so that when the components are aligned with the end face of the tongue in abutment with the abutment surface the peripheral lands are opposite and with a predetermined gap therebetween which is substantially constant in the direction of the clamping force and vibrations of one component relative to the other is ceased when the predetermined gap is substantially eliminated.

7. A method according to Claim 6 wherein one of said peripheral lands is on a peripheral rib formed on the joint face of the respective component.

8. A method according to Claims 7 wherein the peripheral rib is formed on the same joint face as the abutment surface.

9. A method according to Claim 7 or Claim 8 wherein the peripheral rib is formed with slots which allow inspection of the interface between the end face of the tongue and the abutment surface.

10. A method according to any of Claims 5 to 9 wherein the width of the tongue is increased in accordance with the inclination of the joint faces to a plane perpendicular to the direction of the clamping force.

11. A method according to Claim 10 wherein the width of the tongue is varied to provide a substantially constant volume of weld material per unit length of joint face.

12. A method according to any preceding claim wherein said one plastics component includes a flange to connect the manifold to the engine.

13. A method according to Claim 12 wherein adjacent duct portions are interconnected at the flanges and form one single plastics component.

14. A method according to any preceding claim wherein adjacent duct portions of said one plastics component are interconnected by a wall portion of the plenum.

15. A method according to any of Claims 12 to 14 wherein said one plastics component comprises a respective straight duct portion between the flange and the curved duct portion.

16. A method according to any preceding claim wherein adjacent duct portions of said other plastics component are interconnected in the region of adjacent portions of the joint faces.

17. A method according to any preceding claim including the steps of placing the first plastics component in a first tool or jig which supports the first component in the region of the first joint face and placing the second plastics component in a second tool or jig which supports the second component in the region of the second joint face, at least one of the components being flexible so that application of the clamping force causes the joint face of the flexible component to conform to the joint face of the other component and creates pressure on the joint faces over substantially the whole length of the joint face.

18. A method according to Claim 17 wherein said one plastics component has substantially greater rigidity than said other plastics component.

19. An internal combustion engine inlet manifold having a housing defining a plenum, an inlet port to connect the plenum to atmosphere and a number of inlet tracts each connected to and extending from the plenum for connection to an engine to be supplied with air, each inlet tract including a curved tract portion which is defined by a respective curved duct portion of the housing, the housing comprising a first component of plastics material having a first joint face thereon and a second component of plastics material having a second, complementary, joint face thereon, the components being joined by aligning the components with the joint faces

in substantially uniform contact applying a clamping force to create pressure on the joint faces and vibrating one component relative to the other whilst maintaining the clamping force to create friction at the joint faces and thereby join the components by welding of the plastics material, the joint faces being curved in the region of the curved duct so that in said region one component is substantially on the inside of the curve and the other component is substantially on the outside of the curve and arranged so that no part of each joint face is inclined at an angle substantially greater than 60 degrees to a plane perpendicular to the direction of the clamping force.

20. A manifold according to Claim 19 wherein each curved duct portion in use substantially reverses the direction of gas flow through the inlet tract.

21. A manifold according Claim 19 or Claim 20 wherein the joint faces are curved in the opposite direction to the curve of the duct in the region of each end of the curved duct portion.

22. A manifold according to Claim 21 wherein no part of the joint face where curved in said opposite direction is inclined at an angle substantially less than 10 degrees to a plane perpendicular to the clamping force.

23. A manifold according to any of Claims 19 to 22 wherein, before the components are joined, first joint face has a projecting tongue with an end face thereon positioned intermediate two side edges of the first joint face and the second joint face has an abutment surface intermediate two side edges of the second joint face, the arrangement being such that when the clamping force is applied the end face of the tongue abuts the abutment surface.

24. A manifold according to Claim 23 wherein, before the components are joined, the first joint face has a first peripheral land adjacent one of the respective side edges and the second joint face has a second peripheral land adjacent one of the respective side edges, the joint faces being arranged so that when the components are aligned with the end face of the tongue in abutment with the abutment surface the peripheral lands are opposite and with a predetermined gap therebetween which is substantially constant in the direction of the clamping force and vibration of one component relative to the other is ceased when the predetermined gap is substantially eliminated.

25. A manifold according to Claim 24 wherein, before the components are joined, one of said peripheral lands is on a peripheral rib on the joint face of the respective component.

26. A manifold according to Claim 25 wherein the peripheral rib is on the same joint face as the abutment surface.

27. A manifold according to Claim 25 or Claim 26 wherein, before the components are joined, the peripheral rib has slots which allow inspection of the interface between the end face of the tongue and the abutment surface.

28. A manifold according to any of Claims 23 to 27 wherein, the width of the tongue is increased in accordance with the inclination of the joint faces to a plane perpendicular to the direction of the clamping force.

29. A manifold according to Claim 28 wherein the width of the tongue is varied to provide a substantially constant volume of weld material per unit length of joint face.

30. A manifold according to any of Claims 19 to 29 wherein said one plastics component includes a flange to connect the manifold to the engine.

31. A manifold according to Claim 30 wherein adjacent duct portions are interconnected at the flanges and form one single plastics component.

32. A manifold according to any of Claims 19 to 31 wherein adjacent duct portions of said one plastics component are interconnected by a wall portion of the plenum.

33. A manifold according to any of Claims 30 to 32 wherein said one plastics component comprises a respective straight duct portion between the flange and the curved duct portion.

34. A manifold according to any of Claims 19 to 33 wherein adjacent duct portions of said other plastics component are interconnected in the region of adjacent portions of the joint faces.

35. A manifold according to any of Claims 19 to 34 wherein said one plastics component has substantially greater rigidity than said other plastics component.

36. An internal combustion engine inlet manifold substantially as described herein with reference to Figs 1 to 8, Figs 1 to 8 as modified by Figs 10, 11 or 12, Figs 13 to 17 or Figs 13 to 17 as modified by Fig 18 of the accompanying drawings.

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Patents Act 1977
Examiner's report to the Comptroller under Section 17
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Relevant Technical Fields (i) UK Cl (Ed.) (ii) Int Cl (Ed.5) B29C; F02M **Databases** (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Application number GB GB 9415724.5 Search Examiner A C HOWARD Date of completion of Search 16 SEPTEMBER 1994 Documents considered relevant following a search in respect of Claims :- 1-35

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